First results for CONCERTO at APEX!

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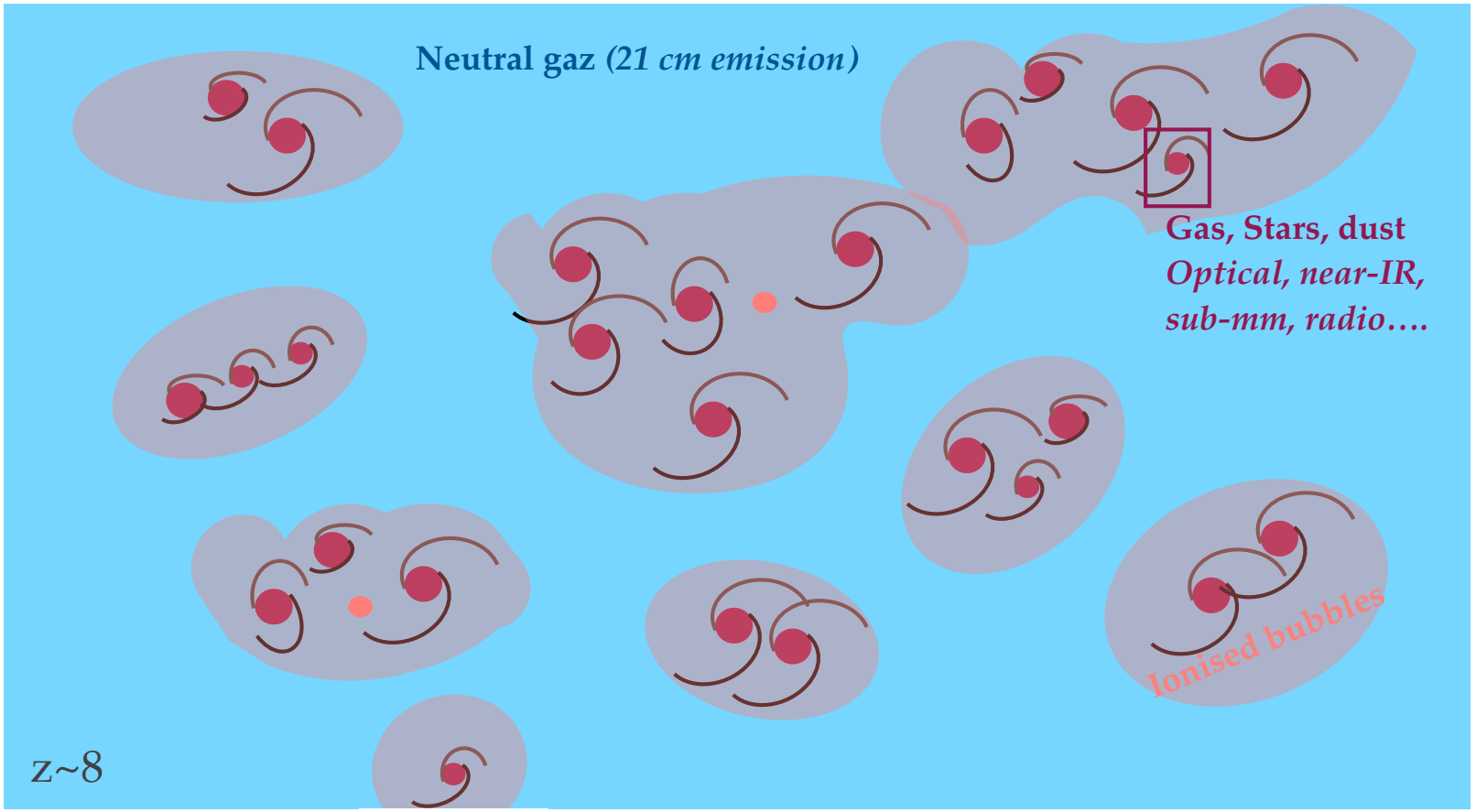
Laboratoire d'Astrophysique de Marseille

Labex FOCUS: General Assembly

20 June 2022

Why embark on the construction of a new instrument ?

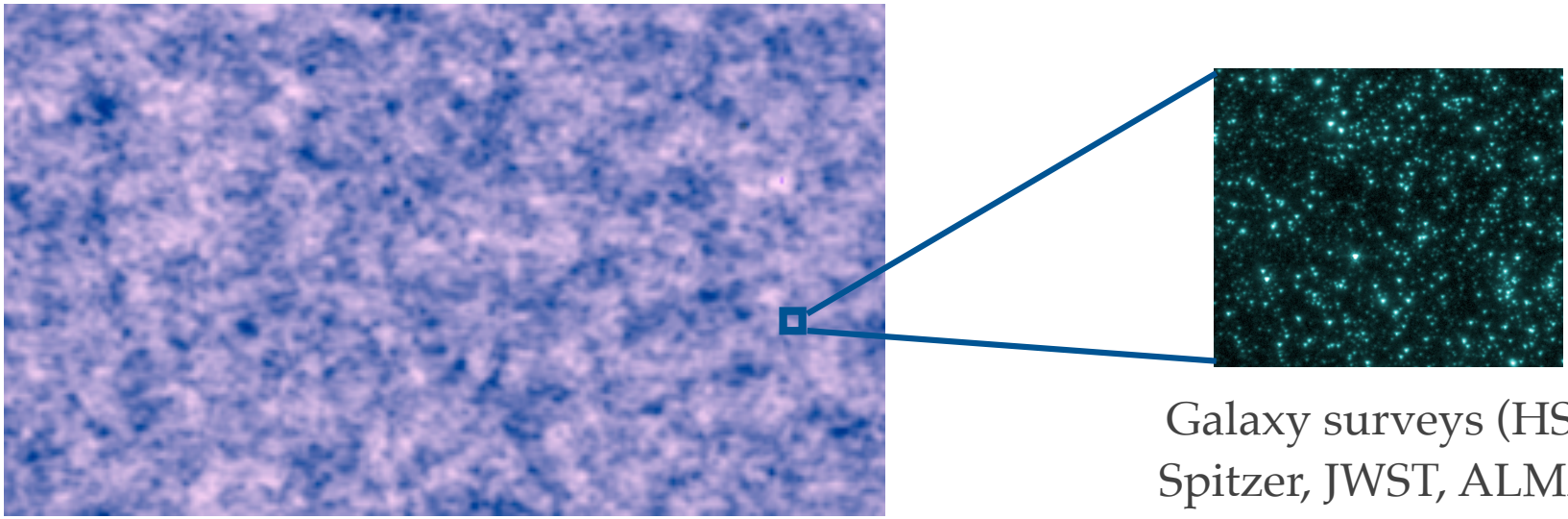
Observing the Epoch of Reionisation



Intensity mapping: basic idea

Measuring the large-scale fluctuations in the emission from a large number of unresolved sources

Intensity mapping: basic idea



Intensity mapping
(confusion-limited surveys)

Galaxy surveys (HST,
Spitzer, JWST, ALMA)

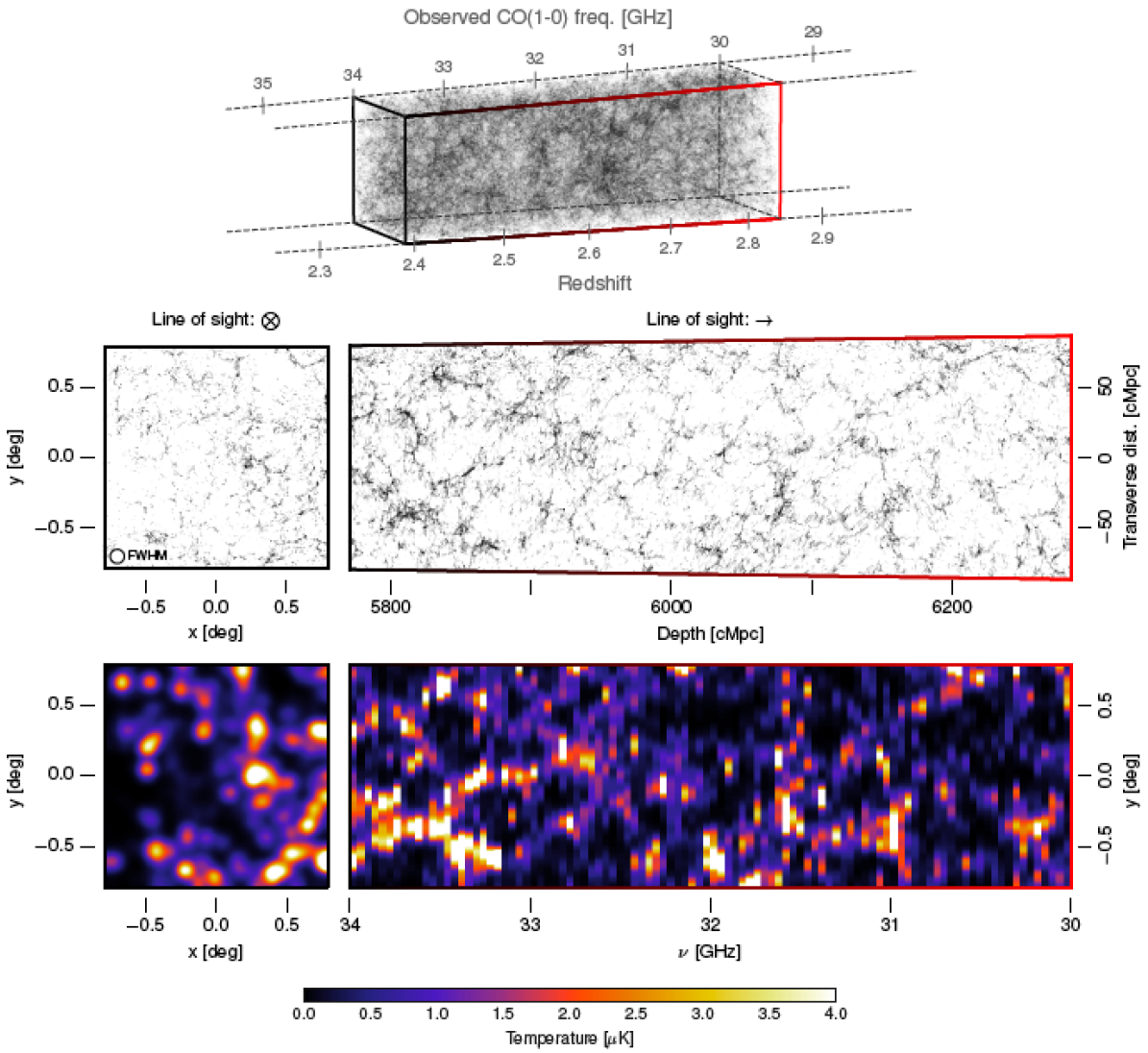
Intensity mapping:

- measure angular fluctuations in the brightness of the sky at a particular frequency

- naturally sensitive to the radiation from faint sources and from the diffuse intergalactic medium

- basic tool : **angular power spectrum**; intensity fluctuations are used to reconstruct the power spectrum of matter fluctuations

Line intensity mapping (3D)



- Brightness temperature fluctuations on the sky in 3D
- Retain redshift information
- [CII] line
  - One of the brightest emission lines in the spectra of galaxies
  - Redshifted into the sub-mm and mm atmospheric windows for 4.5<z<9
  - One of the most valuable tracers of dusty star formation at high redshift

=> $\delta\nu$ =1.5 GHz corresponds to δz=0.05 for [CII] at z=7

Li+2015

CONCERTO*

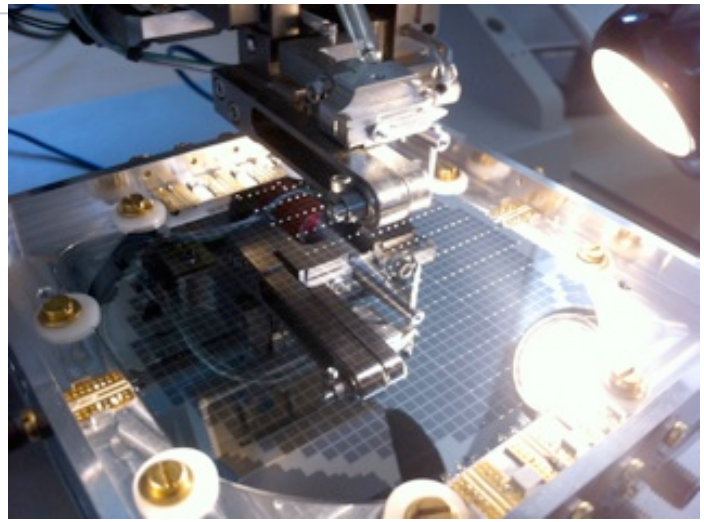
A new spectrometer to map the intensity fluctuations of the [CII] line

LAM, Institut Néel, LPSC, IPAG
And European/Chilean partners (science)

https://mission.lam.fr/concerto/

*CarbON CII line in post-rEionisationand ReionisaTiOn epoch

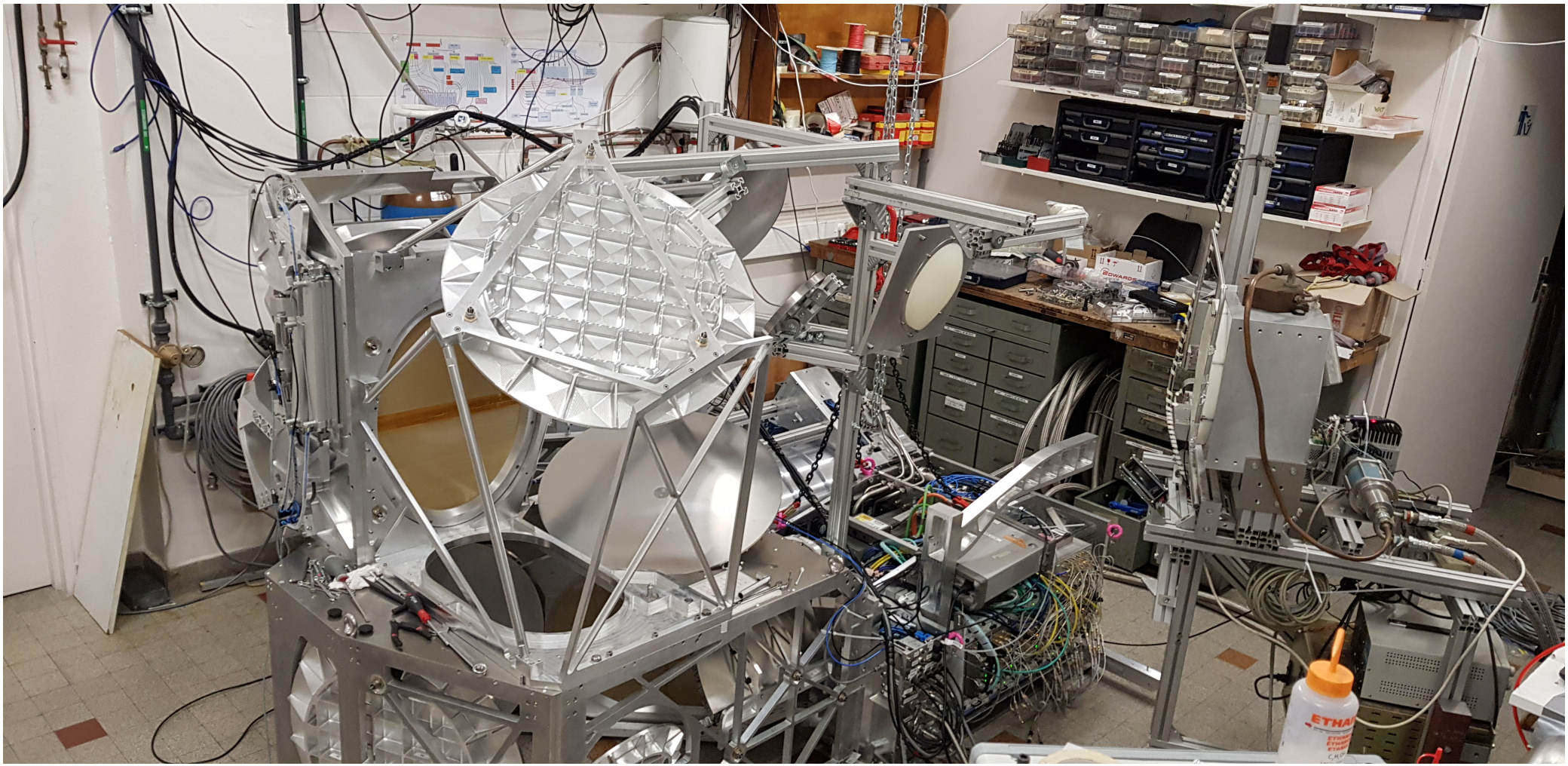
CONCERTO instrument



- Focal plane:
  - Kinetic Inductance Detectors (KID)
  - Success of the NIKA2 IRAM camera
  - FOV D>15', fλ sampling => arrays of 2,152 pixels
- Cryostat:
  - Closed-circle 3He-4He dilution - 100mK
  - 4K stage: achieved using a standard two-stages pulse-tube
- Martin-Puplet interferometer (like a Michelson interferometer but with a movable mirror)
  - Outside the cryostat
  - Spectral resolution (ν/δν): R=100 to 300
  - Perform continuously path interferograms at a frequency of few Hertz or more (2-5Hz)
    - Faster than most of the sky noise - only possible with KIDS
    - "Nominal": 4 interferograms for all pixels of the matrix every second
- A « sub-mm » antenna:
  - APEX telescope, in a very dry area, θ=23" at 305 GHz
  - Frequency range: two arrays, 195-310 GHz for the HF and 130-270 GHz for LF

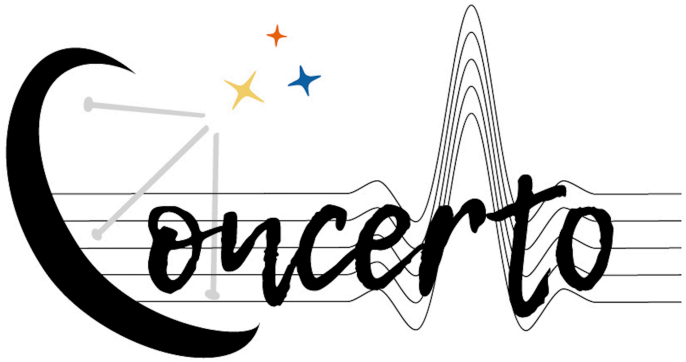
CONCERTO: instrument is complete! (20/10/20)

ERC approval: Feb 2018 — PDR: Feb 2019 — FDR: Feb 2020 — Installation: April 2021



"A wide field-of-view low-resolution spectrometer at APEX: Instrument design and scientific forecast"

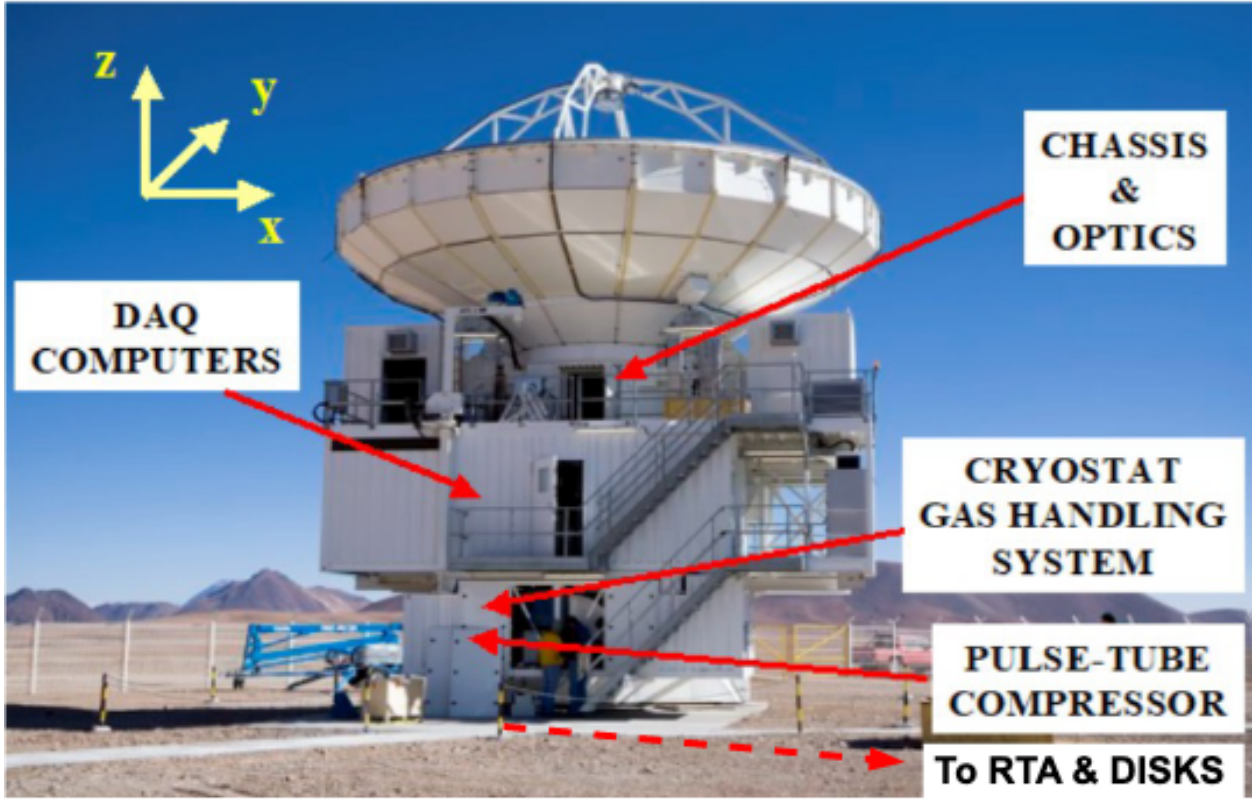
The CONCERTO collaboration, A&A 642, 2020

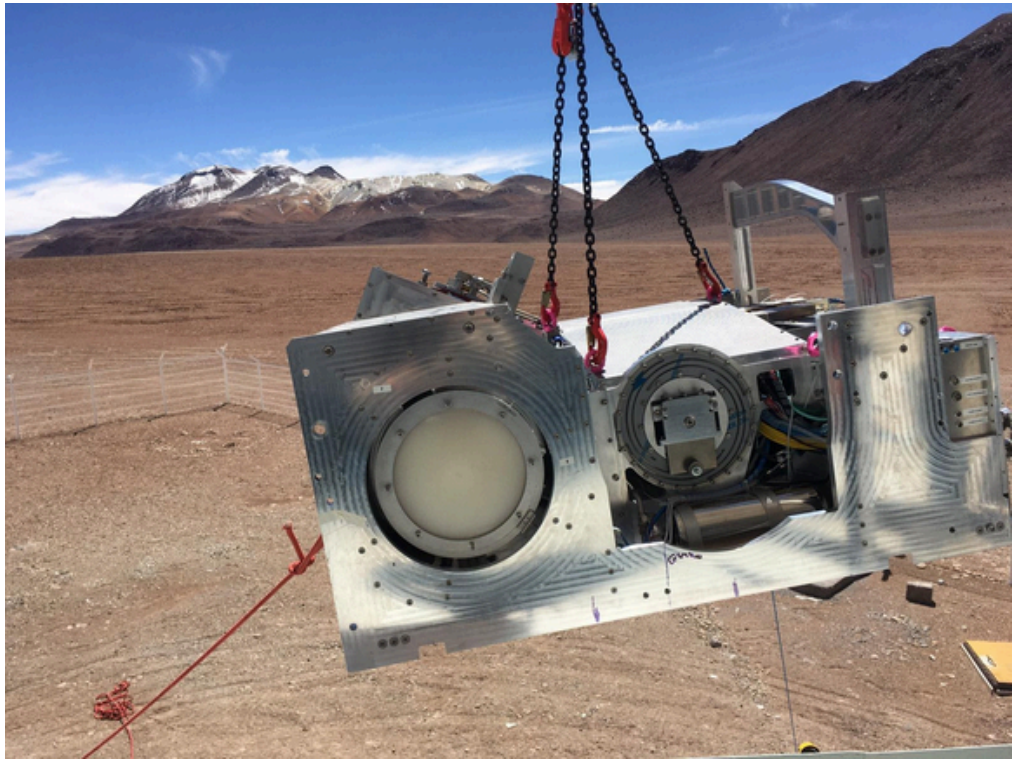


Installation and commissioning

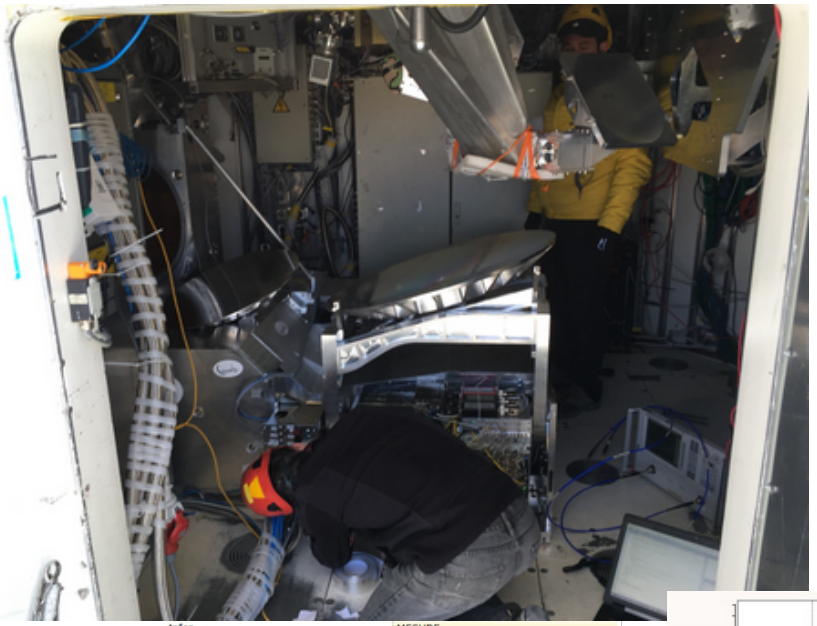
On site:

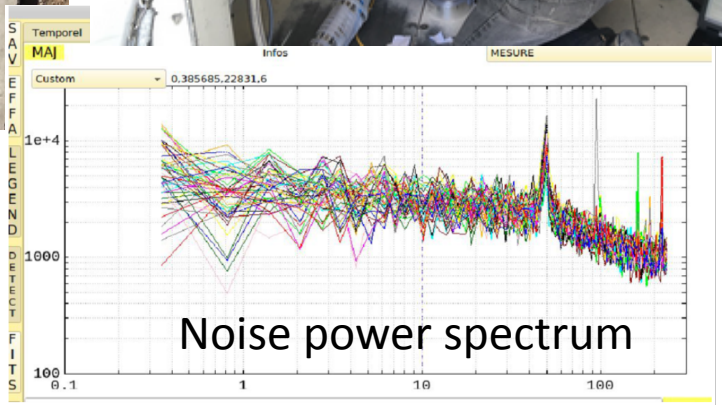
Alessandro Monfardini, Martino Calvo, Johannes Goupy, Andrea Catalano, Julien Boumny, Alexandre Beelen

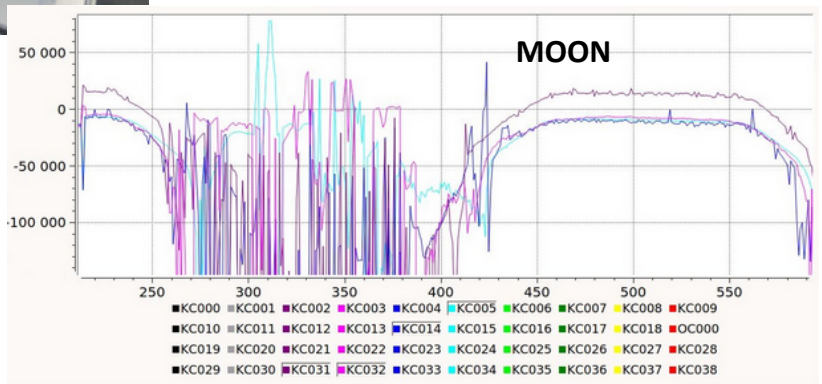

z
y
x
CHASSIS
&
OPTICS
DAQ
COMPUTERS
CRYOSTAT
GAS HANDLING
SYSTEM
PULSE-TUBE
COMPRESSOR
To RTA & DISKS



Shift « P » - 06/04/2021 to 15/04/2021





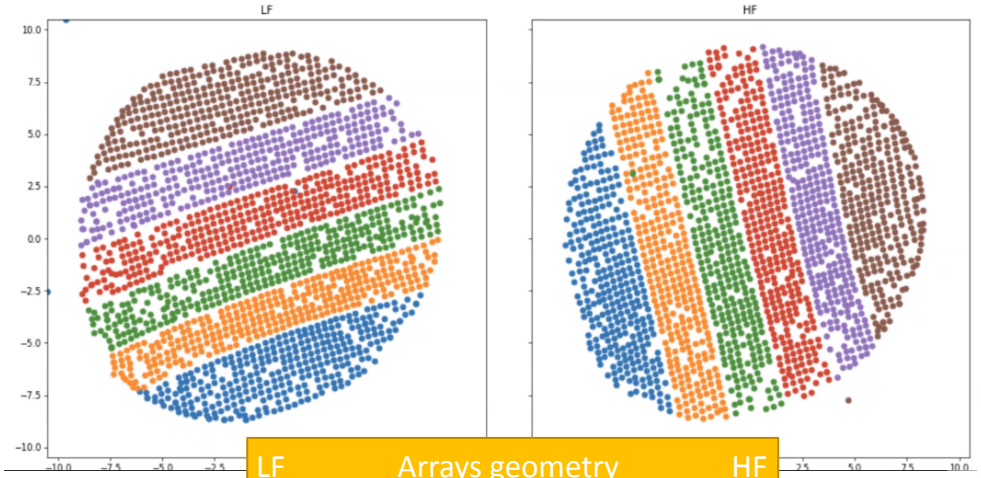


MOSTLY: Unpacking, installation in the C-cabin, instrumentations and compressors containers, connection, cooling-down, first technical light on Sky and Moon, running underground cables

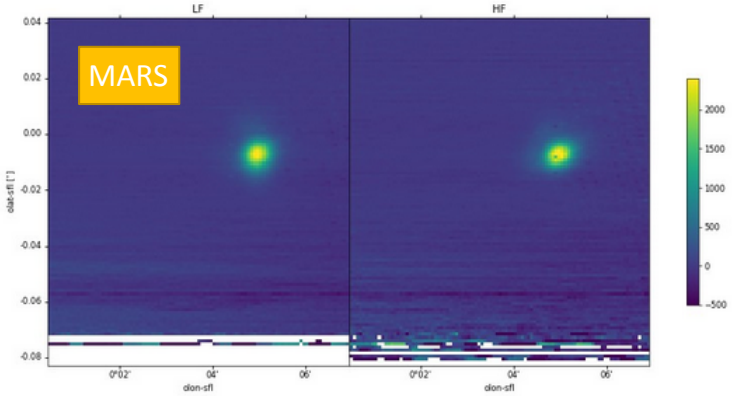
→Cryostat cold, resonances OK, noise floor OK, 50Hz noise observation (not present with cap), seen response from Skydip, observation of the Moon.

Shift « Q » - 17/04/2021 to 25/04/2021

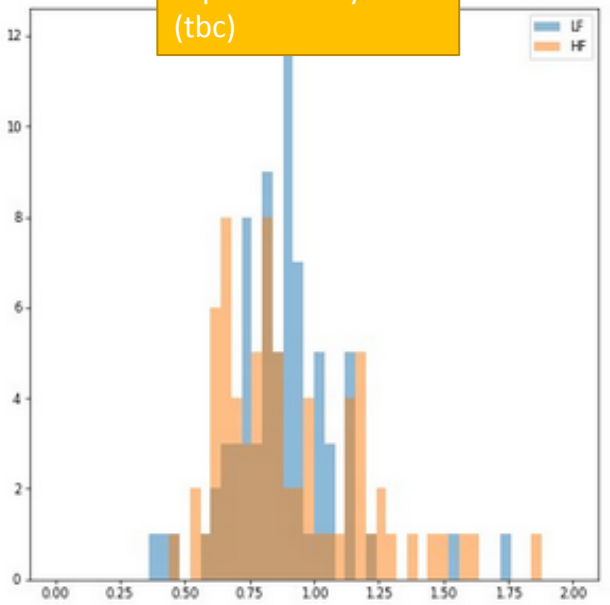
Electronics maintenance



LF Arrays geometry HF



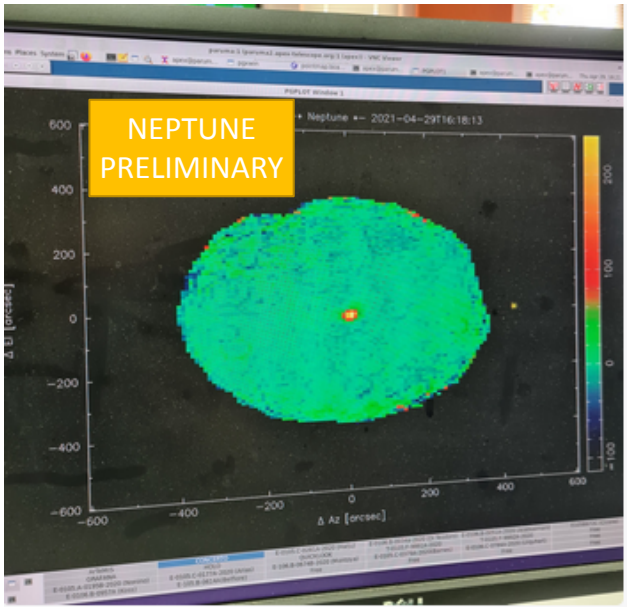
Interferometry Efficiency compared to photometry mode (tbc)

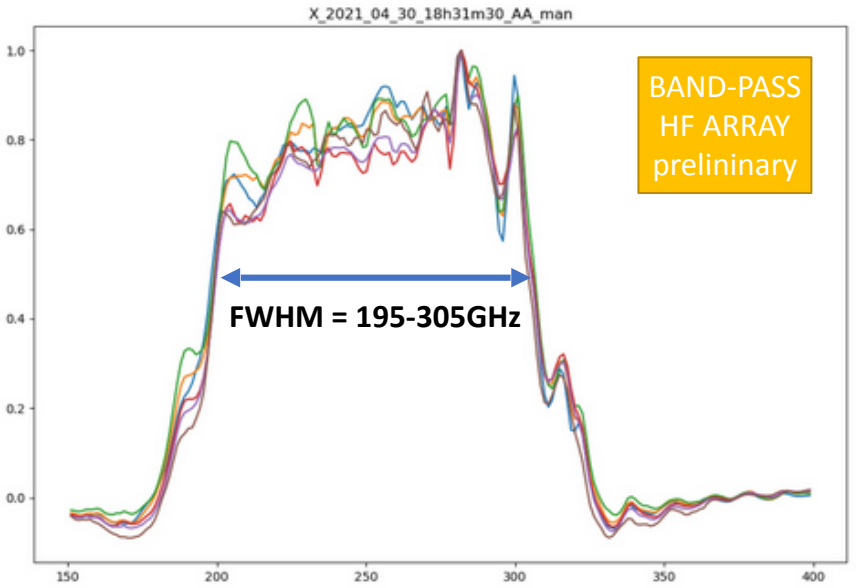


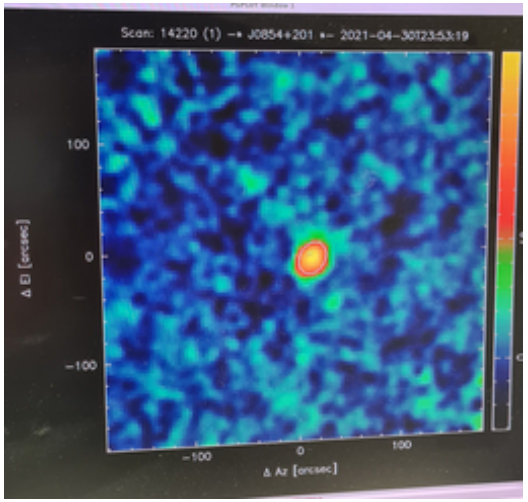
MOSTLY: installation in servers room, detectors settings, alignments, fixing various electronics problems, first focussed light, investigation of 50Hz noise, geometries, DAQ debug etc.

→Identified the MENERGA origin for part of the 50Hz noise, seen Jupiter and Mars, detectors response OK, fixed problems on electronics, interferometry is good, geometries…

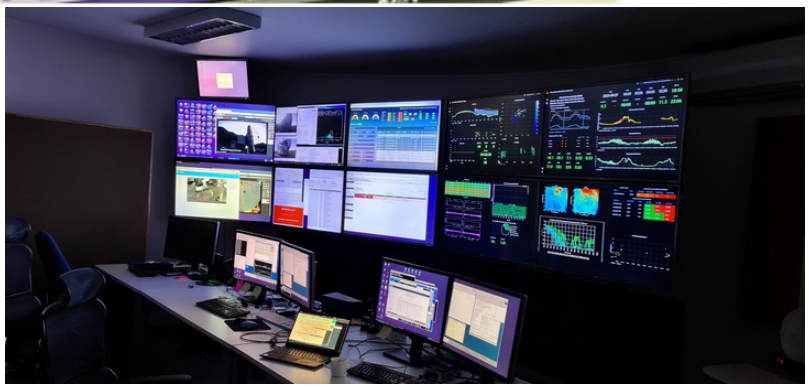
Shift « R » - 27/04/2021 to 06/05/2021

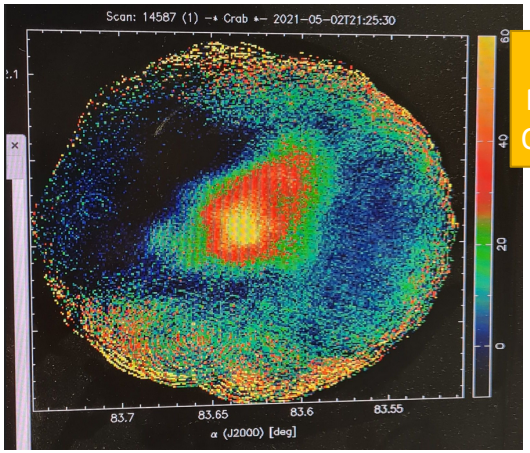






J0854+201 – 2.5Jy @233GHz
Pointing scan 35 seconds
(start of pointing run)

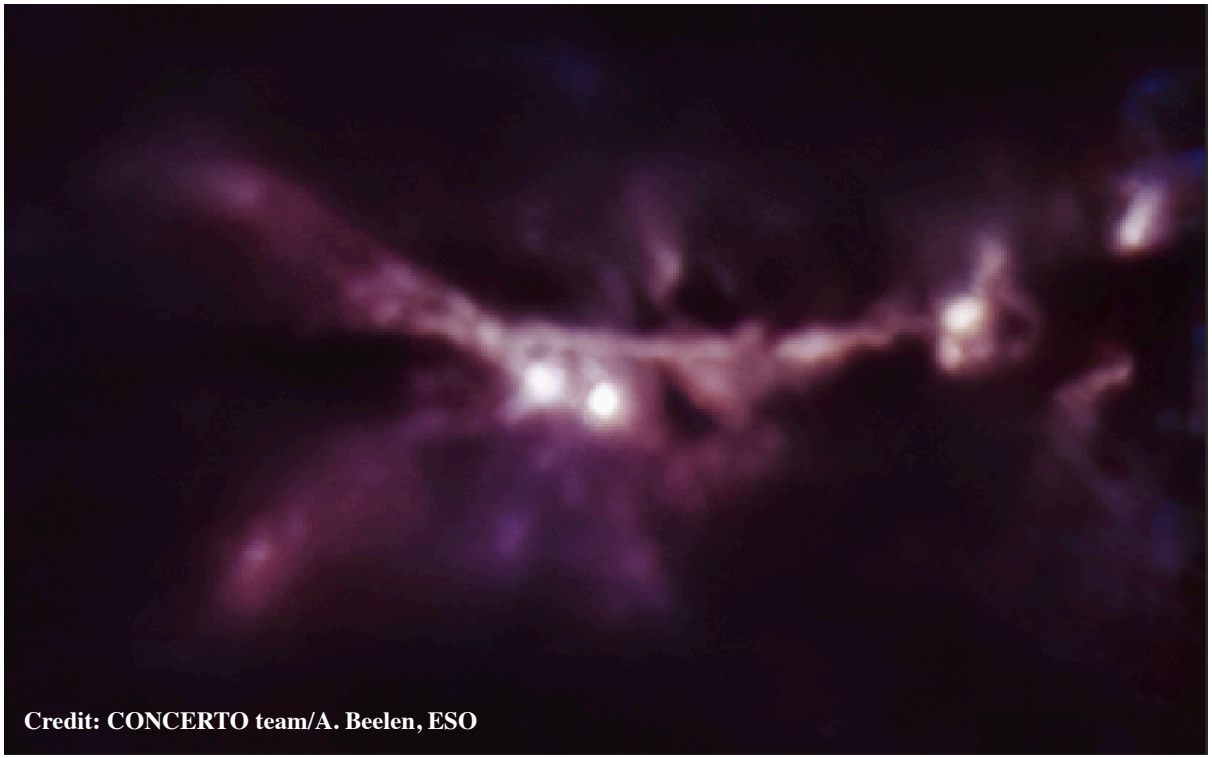




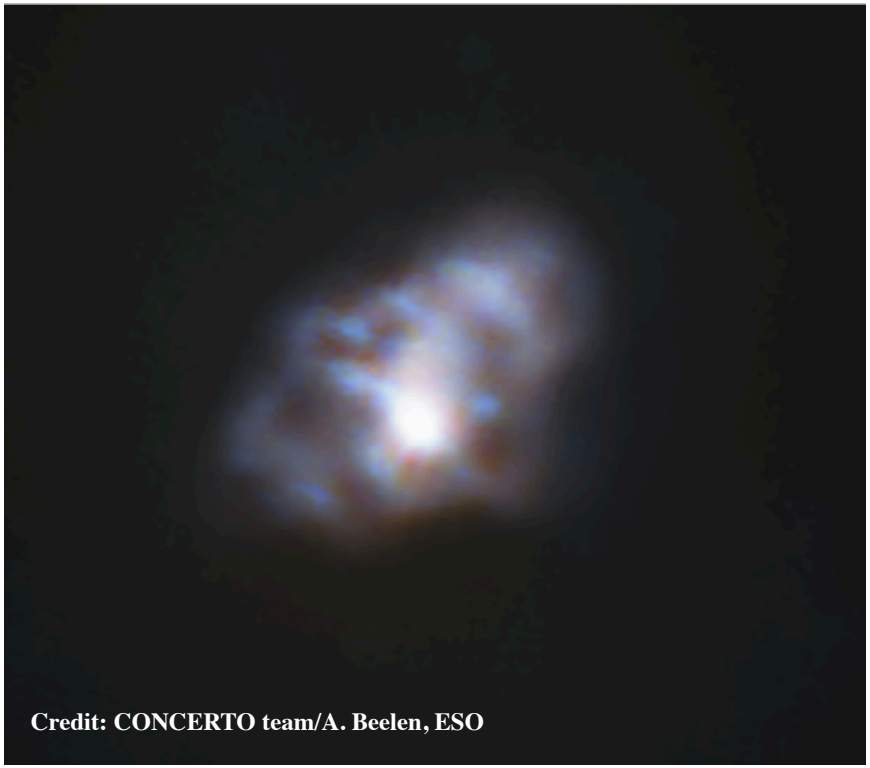
MOSTLY: observations, investigation of 50Hz noise, software, data analysis, pointing model

→Observed some fainter and extended sources, focus, bandpass HF is OK, bandpass LF on-going, pointing model…

→Demonstrating remote observations

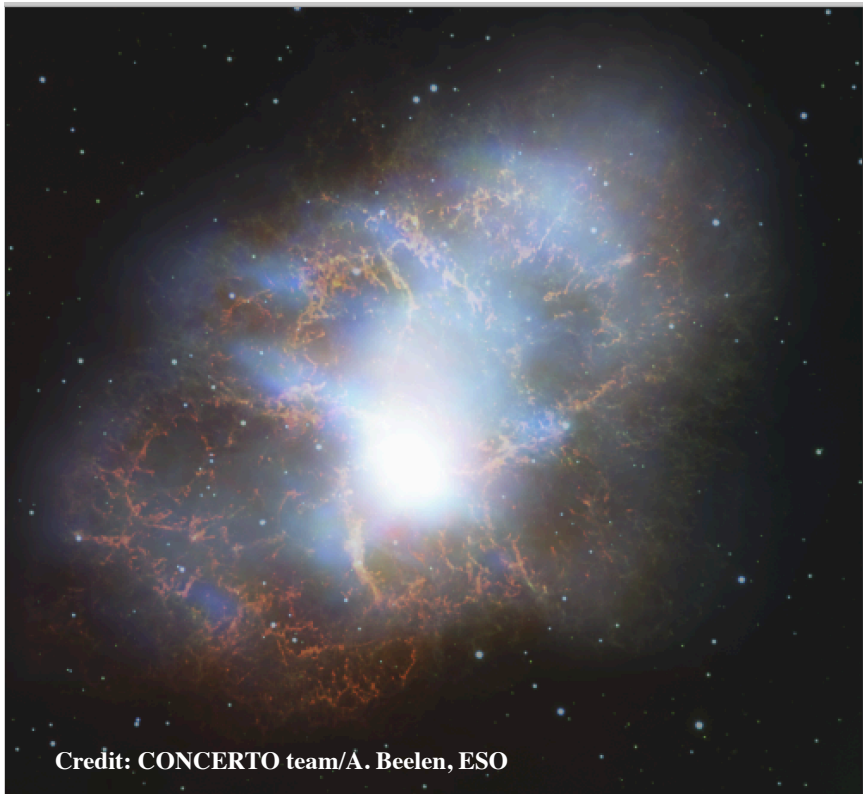


Credit: CONCERTO team/A. Beelen, ESO



Credit: CONCERTO team/A. Beelen, ESO

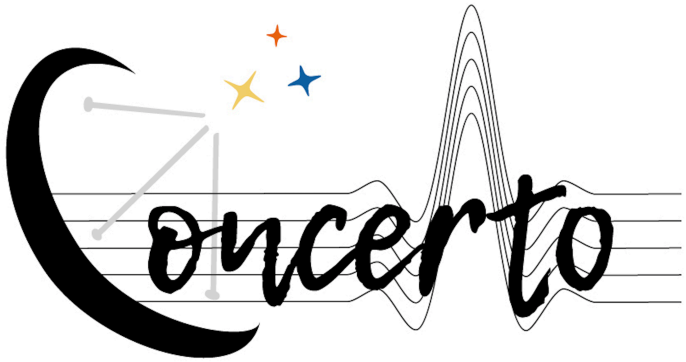
Credit: ESO/J. Emerson/VISTA Acknowledgment: Cambridge Astronomical Survey Unit



Credit: CONCERTO team/A. Beelen, ESO

SUCCESS !! A human adventure….

CONCERTO is a completely crazy project!



One year later….

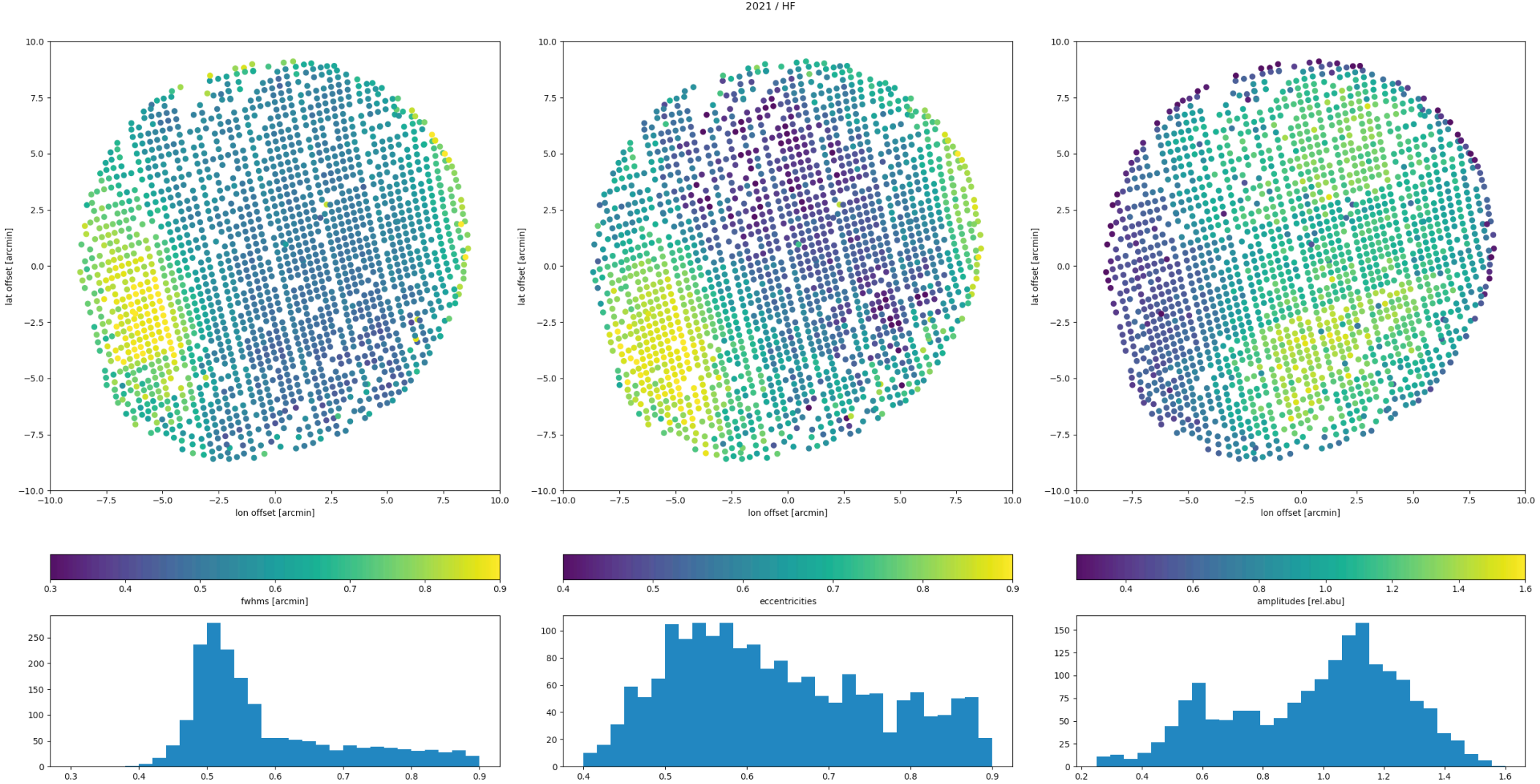
Observations

- First “astro” observations during commissioning: AS2UDS (24/06), RXCJ1206 (26/06)
- From July to December 2021: 5 remote observing runs and 1 on site. **Routine observations!**
- Start again on April 20, 2022 (OSO)
- Simple procedures to start and prepare the instrument before starting the observations. Takes less than 15 minutes. Operating and monitoring the instrument is very smooth: APEX_manager and interface with instrument setup (acquisition) and quick look (signal, PSD)
- P108: Observations of 2 galaxy clusters
  - RXJ1347: ESO Open time + Abell 2744: CL time
- P109: 7 proposals (ESO) + 1 (CL) submitted
  - 2 ESO were accepted (PIs: Annie Zavagno and Emmanuel Artis for 110.5 hours) + 1 CL
- P110: 6 proposals (ESO for 266.1 h) submitted

- + COSMOS field (LP):
  - Starting the OSO+CL+ESO LP on the COSMOS field on 15/07/2021
  - So far: 369 hours on the COSMOS project (avec une efficacité de 79%)

Beam maps (18 combined)

In photometry only (mirror is not moving): 115 GiB, ~ 50 minutes

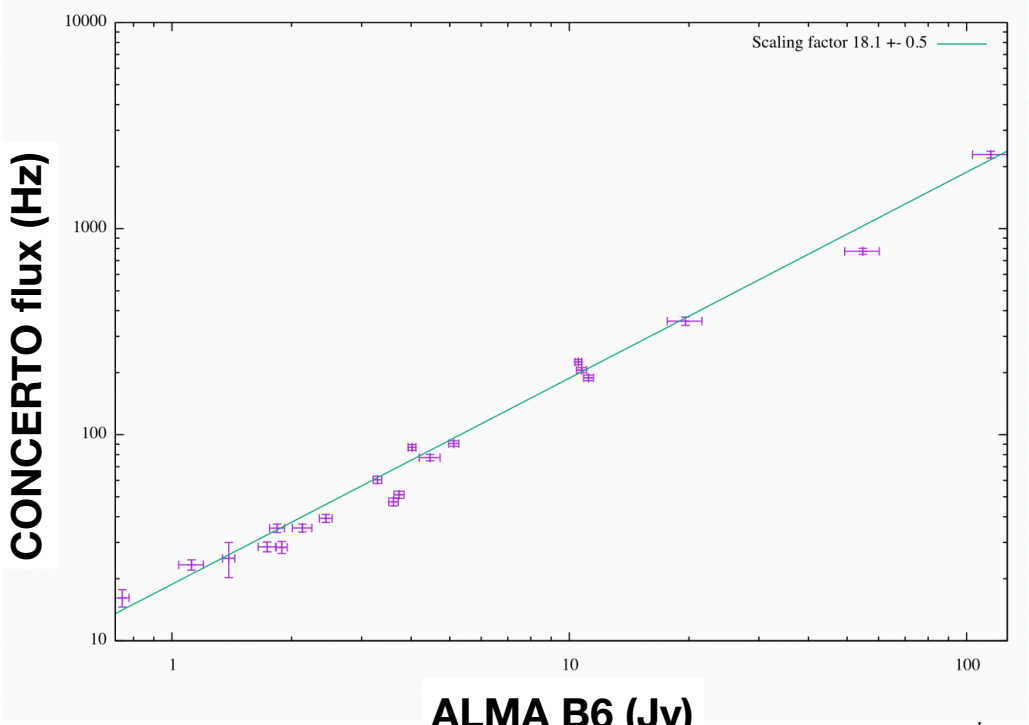


From a beam map on Mars:

- KIDS kept (after reading, i.e. some KIDs are not in the param.ini file): 86.4 %
- Among them: Good (unflagged): 76.2 %

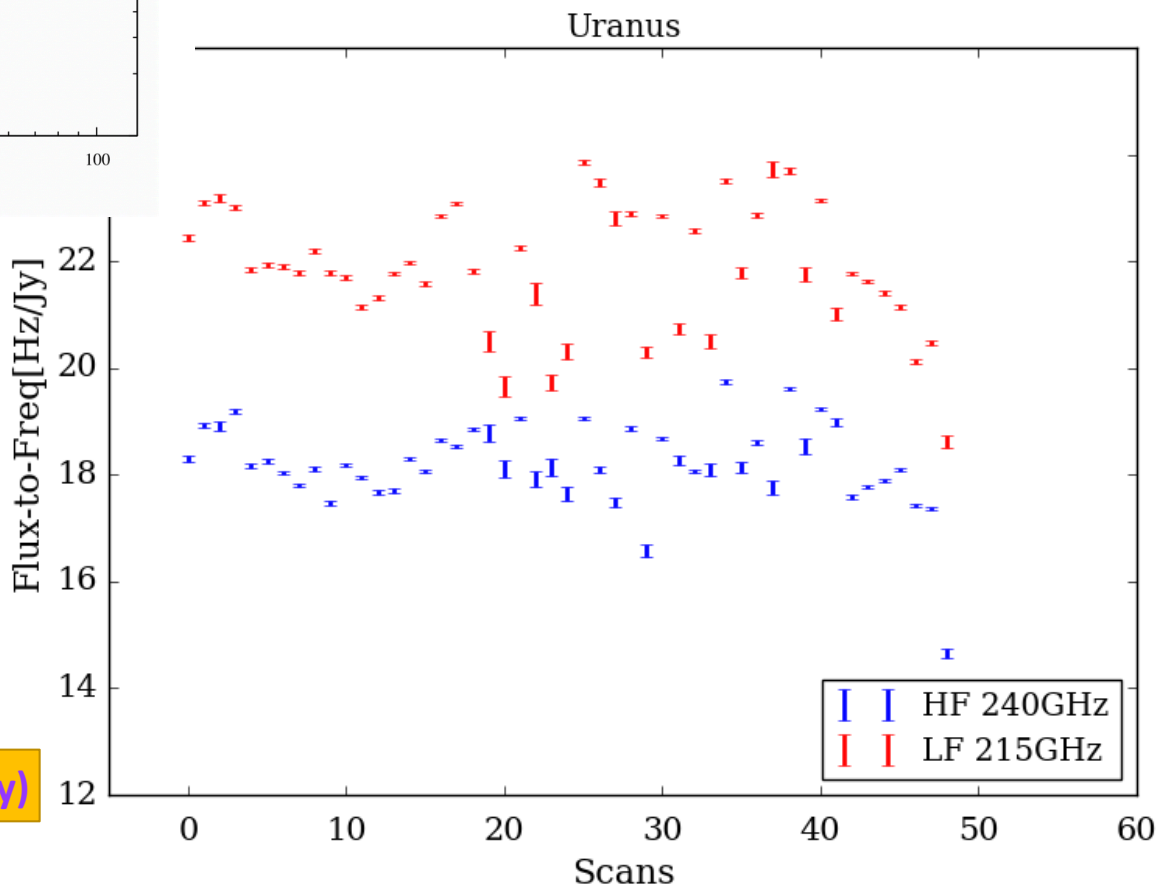
From Alexandre Beelen

Absolute calibration



17 QSOs (ALMA B6) + Mars/Neptune/Uranus

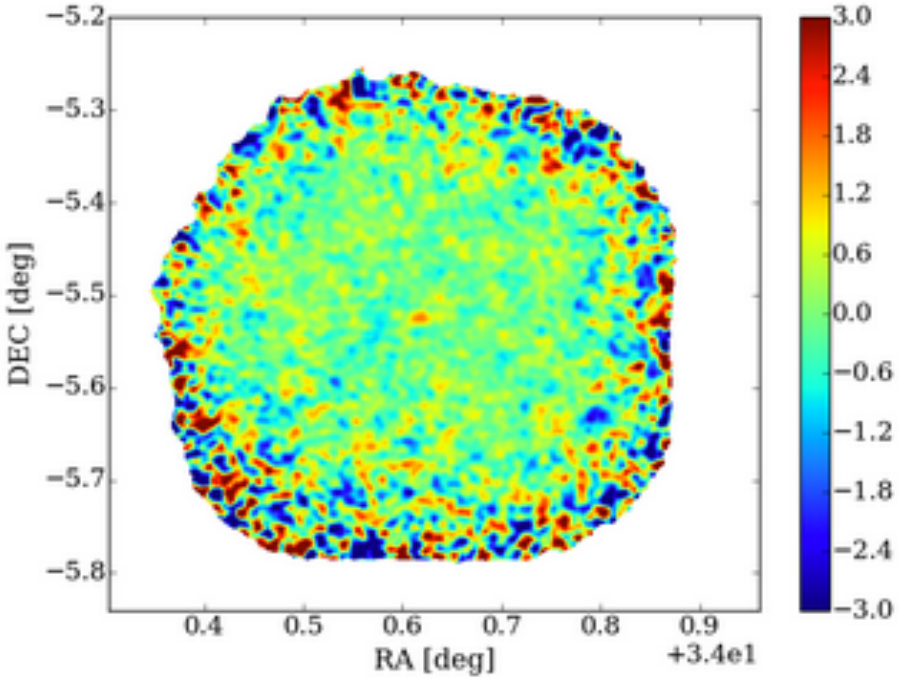
From Andreas Lundgren and Wenkai Hu



Uranus: 49 scans (photometry and spectroscopy)

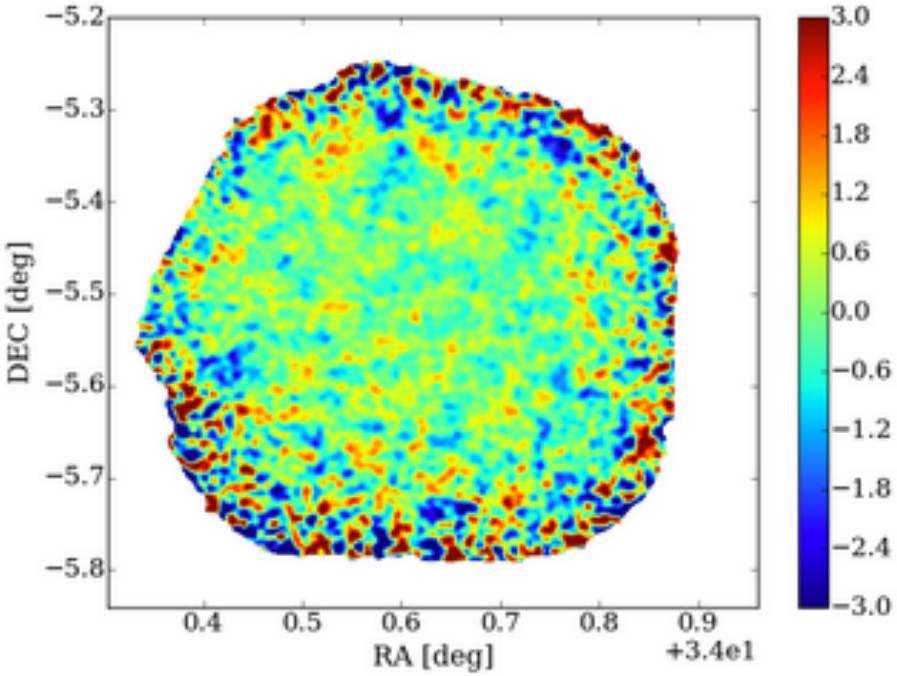
AS2UDS

HF



SNR = 3.3 - 4.6

LF



SNR = 2.9 - 3.7

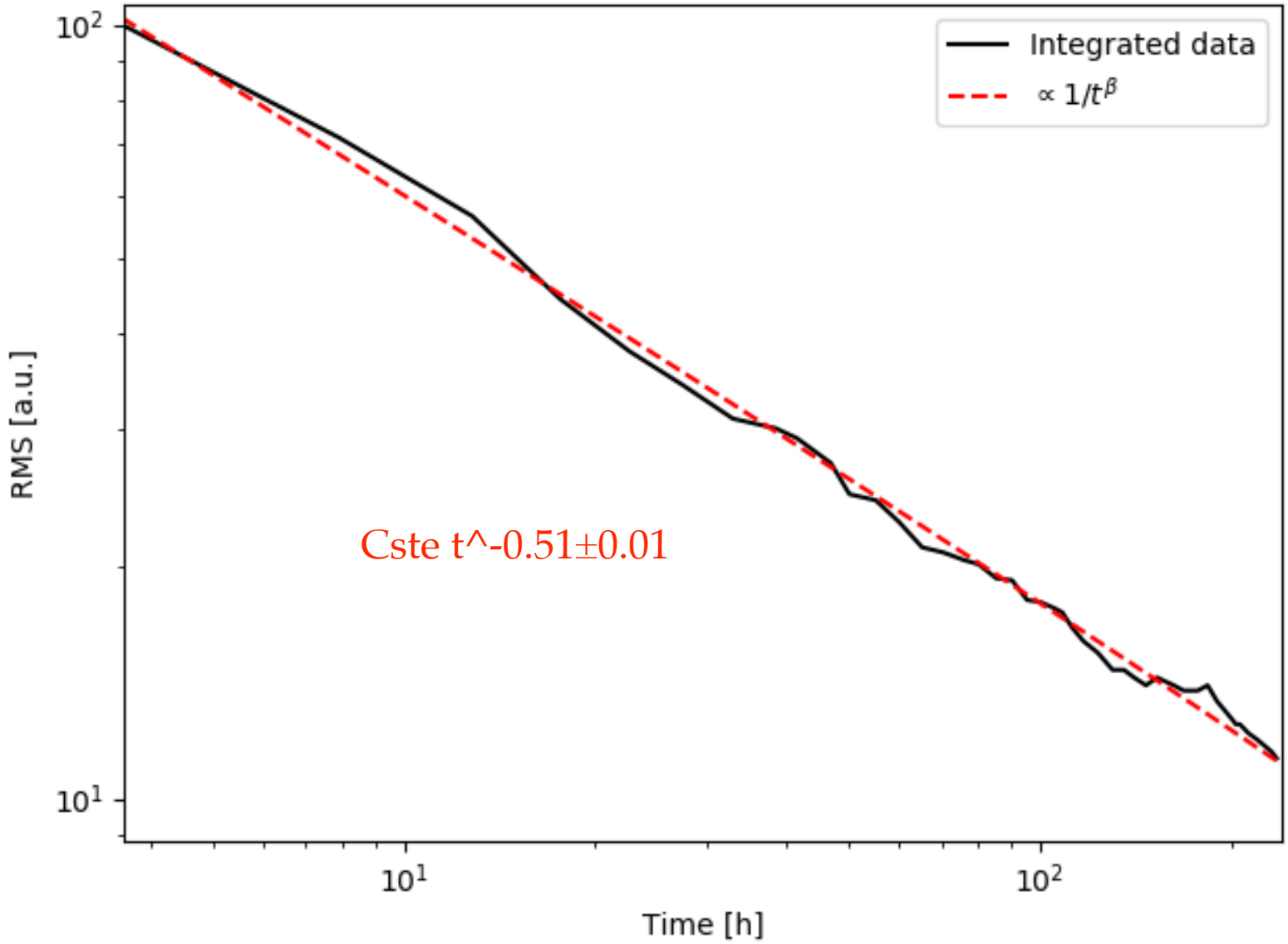
Expected flux at 1.2mm (250 GHz): 13.6-15.2 mJy
=> Should see the source at 3.3-3.7 sigma.

Sensitivity measured on sky (photometric mode) perfectly in line with expectations.

From Wenkai Hu

COSMOS Field (1.4 Sq. Deg.)

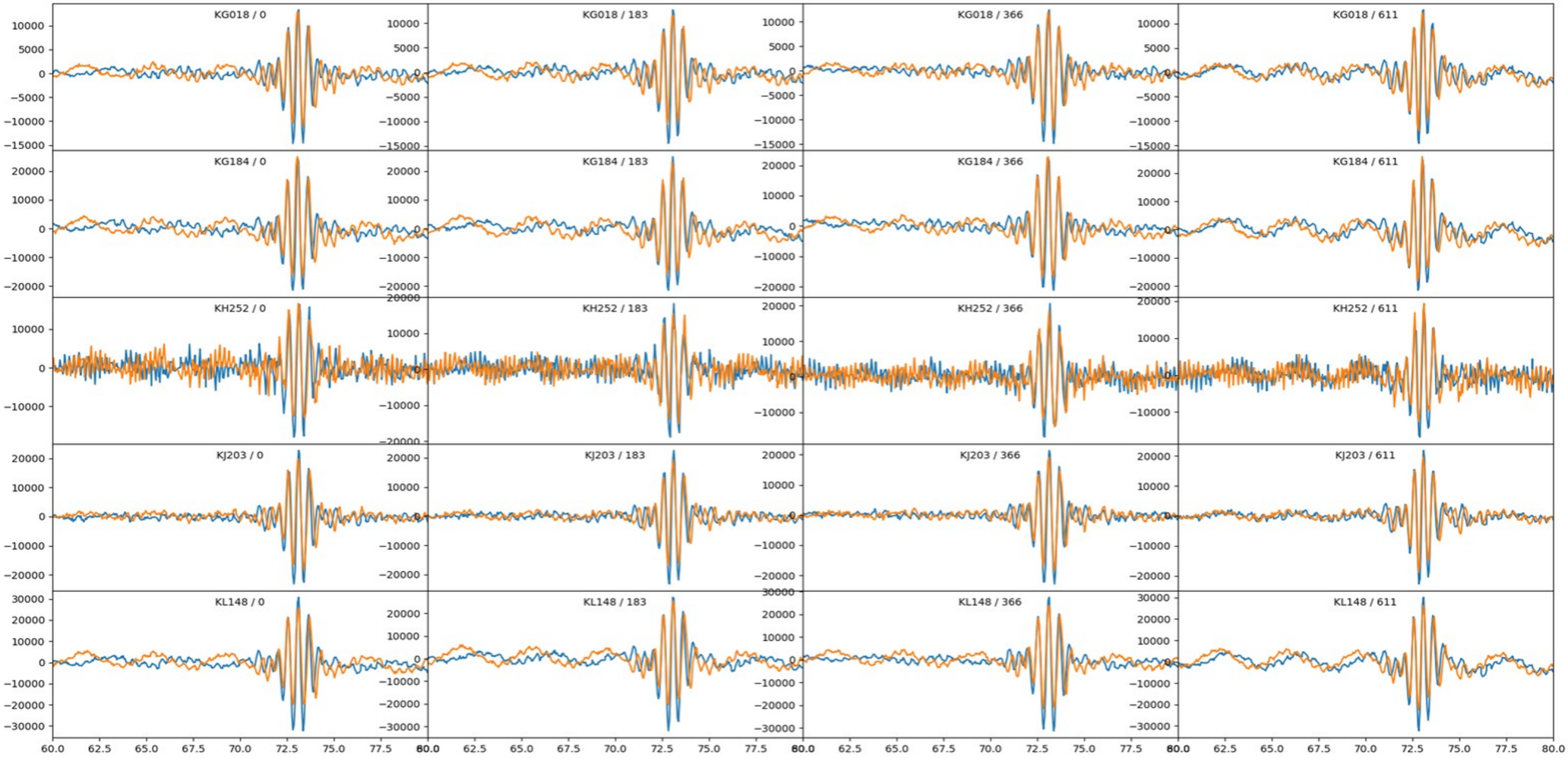
RMS central KIDS HF & BOA



From Andreas Lundgren and Alessandro Fasano

A strong systematic effect

- KIDS timelines show strong 47ish Hz noise

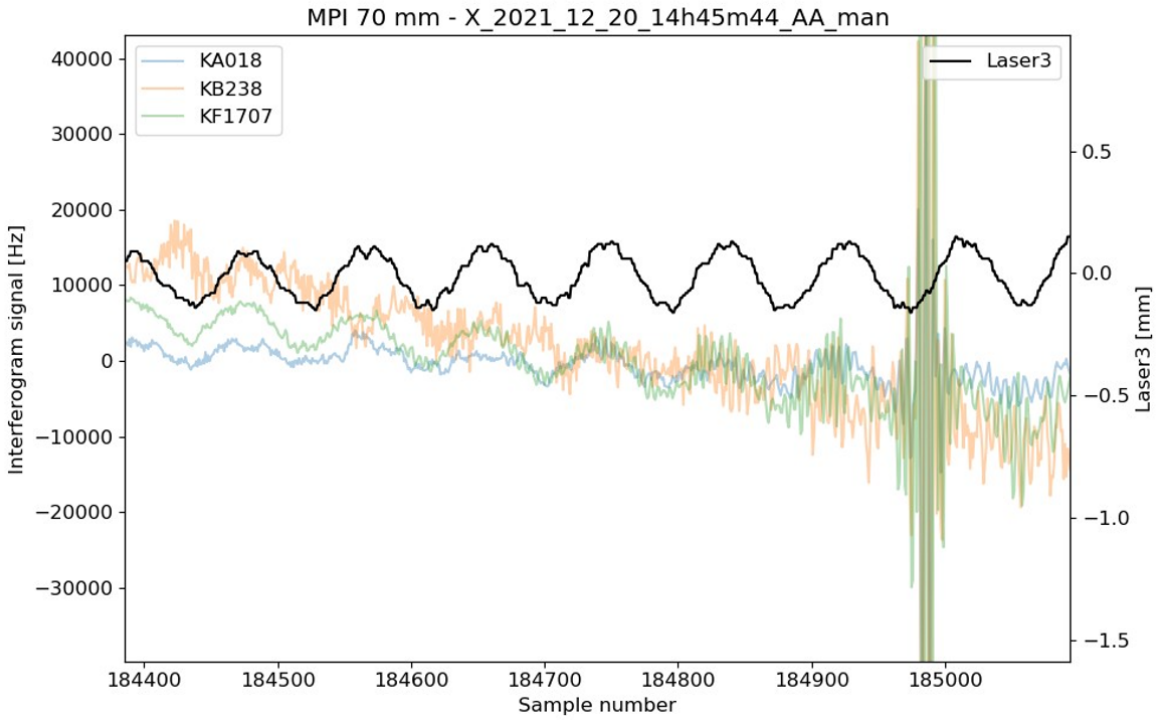


A strong systematic effect

Acoustic vibrations/deformation of the polariser could explain it all!

- The main laser is not measuring the actual optical difference
  - Problems to get the zero-path difference of the interferograms
- Additional noise in the KIDS timeline:
  - Suppression of the noise when MENERGA is off
  - Additional noise when MPI is on

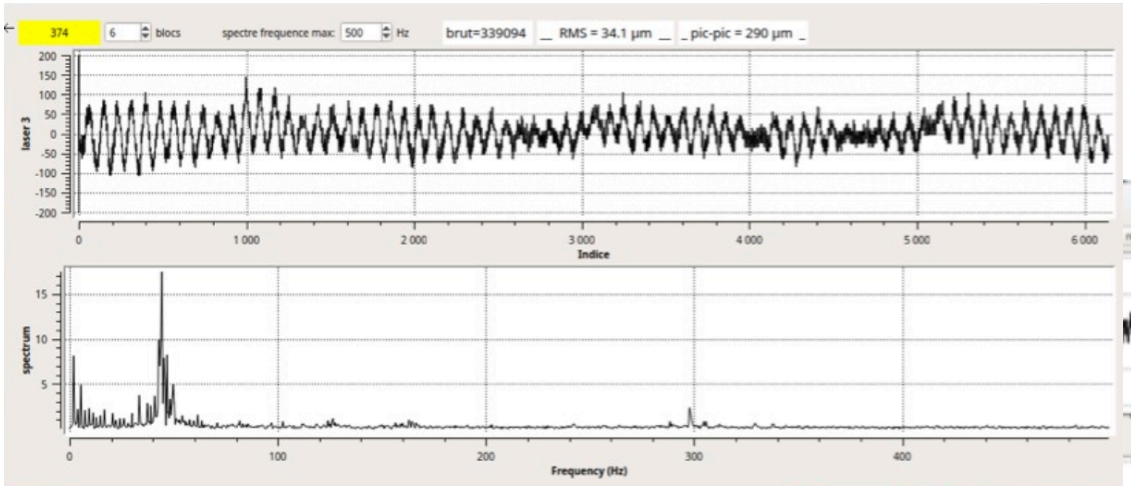
A new laser!
(Dec 2021)

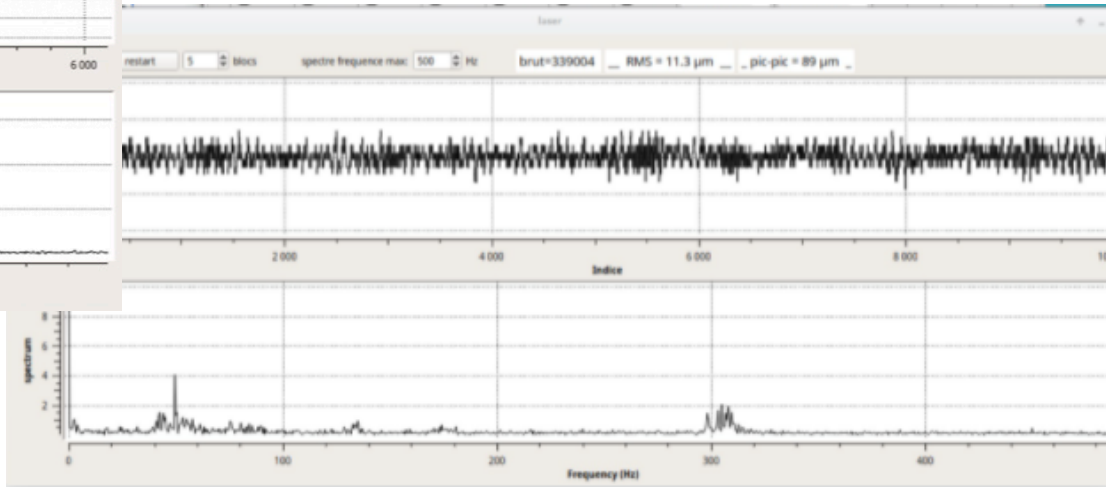


Polariser vibrations - Counter Action

Installation of a speaker pointing towards the membrane (Jan 2022)

- Can excite the membrane
  - Allows us to derive KIDS response to membrane displacement
  - Allows us to derive effective correction to OPD
- Can be use in close-control loop to reduce membrane vibration
    - Decrease membrane rms by x3 (limited by the laser precision)





One year later….

We just got a hand on the first and **strongest systematic effect** impairing our ability to derive spectra with confidence.

With Laser3 and the “counter action”. sensitivity in spec already within 50% of expectation.

Observing, observing, observing …. in hurry because of the end of CONCERTO in Dec 2022.

Last Call for ESO Observing Time on APEX

Published: 25 Feb 2022

CONCERTO team

Instrument: A. Monfardini (Institut Néel), A. Benoit (IN), Julian Bonmy (LPSC), O. Bourrion (LPSC), P. Camus (Institut Néel), M. Calvo (Institut Néel), A. Catalano (LPSC), F.-X. Désert (IPAG), J. Garcia (LAM), G. Garde (LPCS), J. Goupy (Institut Néel), C. Hoarau (LPSC), J. Marpaud (LPSC) J.-P. Leggeri (Institut Néel), L. Prieur (LAM), D. Tourres (LPSC)

Pipeline, instrument model: A. Beelen (LAM), F.-X. Désert (IPAG), G. Duvauchelle (LAM), A. Fasano (LAM), W. Hu (LAM), G. Lagache (LAM), J. Macias-Perez (LPSC), N. Ponthieu (IPAG)

Infrastructure: J.-C. Lambert (LAM), T. Fenouillet (LAM)

APEX: C. De Breuck (ESO, Garching), C. Duran (ESO APEX)

Admin: L. Todorov (LAM), C. Vannier (LPSC)

Science: All above + M. Béthermin (LAM), A. Gkogkou (LAM), M. Van Cuyck (LAM) + many collaborators: M. Aravena, F. Arrigoni Battaia, J. Conway, C. de Breuck, J.-G. Cuby, A. Ferrara, M. Ginolfi, K. Harrington, R. Herrera-Camus, C. Horellou, E. Ibar, K. Knudsen, G. Mellema, A. Pallottini, A. C. Posses Nascimento, D. Quinatoa, C. Schimd, M. Solimano, L. Vallini, F. Walter, A. Weiss, E. Zackrisson